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A perspective on E-Learning and Cloud Computing

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Abstract

Computer based laboratories are an important component of the e-learning environment. With the introduction of Cloud Computing technologies more and more laboratories move into the cloud, known as virtual laboratories. While there are many benefits for using virtual laboratories, there is also an increase complexity regarding the usage of them. There are many cloud management systems (Cloud MS) which add an extra layer of complexity to the e-learning experience both from the perspective of the teacher and of the student. The purpose of the study is to identify ways to improve the learning process through the use of cloud computing technologies, while reducing the complexity associated with these technologies the main focus is about the requesting, creation, deployment, monitoring and management of virtual laboratories using Cloud Computing. IBM Tivoli Service Automation Manager and VMware Hypervisor are used for building a private cloud. Moodle is used as the Course Management System (Course MS). The proposed Virtual Laboratories Cloud System (VLCS) offers one possible way to improve the learning process by using Cloud Computing to offer Virtual Laboratories as a Service (VLaaS). The VLCS has the main goal of offering virtual laboratories while increasing the cloud resources utilization. The proposed VLCS creates a new link between cloud computing and e-learning by providing virtual laboratories as a service to as many users as possible while increasing the utilization of private cloud resources. This approach offers the opportunity to enhance the e-learning experience with new ways of teaching.

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Keywords: Cloud computing, e-learning, virtual laboratories, virtual laboratories as a service;

1. Introduction

The adoption of cloud technologies in the academic environment has the potential of offering new opportunities for improvement and innovation of the learning process. The area on which this paper focuses is about the requesting, creation, deployment, monitoring and management of virtual laboratories using cloud computing.

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Currently, most of these activities can be handled by using some sort of Course Management System (Course MS), like IBM Tivoli Service Automation Manager (TSAM) [1], VMware vCloud Suite [2], Microsoft System Center 2012 [3], or Apache CloudStack [4]. All of these systems where designed to best manage a Cloud Computing platform at the infrastructure level, in other words for offering Infrastructure as a Service (IaaS) [5].

IaaS represents the most basic cloud-service model which generally means the offering of cloud resources as services, for example, virtual machines. With the use of IaaS the level of technical knowledge required by the end-user is the highest when comparing with the other two basic cloud-service models, Platform as a Service (PaaS) [7] and Software as a Service (SaaS) [8].

A virtual laboratory, in this case, is considered to be an environment composed of specific hardware and software configuration which provides support for an academic course. Usually, a virtual laboratory will be represented by a virtual machine (hardware resources), the Operating System (OS) and the required application and files (software resources).

At the Faculty of Automatic Control and Computer Science, University Politehnica of Bucharest, the use of virtual laboratories was implemented and tested on the IBM CloudBurst [9] platform which uses VMware as a hypervisor and IBM TSAM as a Cloud MS. Even though the basic functionality of the virtual laboratories is working (creation of virtual machine templates, deployment of virtual machines based on templates), there are still functionalities that are missing or tasks that need manual actions in order to be completed.

In order to address these issues, the VLCS has been designed and will be presented in the following section of this paper.

2. Virtual Laboratories Cloud System

The VLCS is a software system design to fill the needs of an academic environment by creating a link between a Cloud MS and a Course MS or E-Learning System, for example Moodle [10]. VLCS will represent a new layer for creating and managing virtual laboratories. While a Cloud Management System (either commercial or open-source) is mandatory, the existence of a Course Management System is highly recommended but not necessary for the utilization of the VLCS.

2.1. VLCS objectives

The main objective of the VLCS is to maximize the utilization of private cloud resources in order to offer access to virtual laboratories to as many users as possible. This can be done by efficiently monitoring and scheduling the usage of cloud resources.

The second objective is to allow the teaching staff to focus on the development of new, innovative learning processes and curricula without having to worry about the complexity behind the VLCS, in particular the cloud management tasks.

The third objective of the VLCS is the ability to interact with any (or as many) Cloud MS and Course MS as possible. In the first stage of development, VLCS will provide support for the following Cloud MS VMware vCenter, IBM TSAM and Microsoft System Center 2012. Regarding the Course MS or e-Learning System, VLCS will provide support only for Moodle through a dedicated plugin.

2.2. Virtual Laboratory as a Service

VLCS focuses on virtual laboratories from the end-user or educational perspective. For this reason VLCS introduces the concept of Virtual Laboratories as a Service (VLaaS).

VLaaS can be viewed as a new cloud service model which extends the IaaS by adding e-learning functionality. Using VLaaS, end-users still get cloud services as virtual machines and other resources, with the important difference that these services are allocated to specific users or user groups only in the context of a course or laboratory.

2.3. Virtual laboratories management

A virtual laboratory, core entity of the VLCS, is composed of hardware and software resources which are hosted in a cloud environment, private, public or hybrid. The VLCS has support for the following scenarios regarding the management of virtual laboratories: predefined virtual laboratory using virtual machine templates or custom virtual laboratory using on-demand virtual machines and additional software.

The creation of preconfigured virtual machine templates, the most time consuming activity, requires the configuration of the virtual machine (hardware configuration), installing the OS, the hypervisor tools or drivers, the antivirus solution, adding the required applications and extra files (e.g. laboratory manuals, course presentation).

The creation of custom virtual machine on-demand means that a virtual machine is created based on user requirements without using a preconfigured template, if resources are available and the administrator approves it (manually or automatically). The end-user can choose the hardware resources needed, like the number of CPUs, number of cores per CPU, memory, storage space, networking capabilities. The software resources that the end-user could choose are related to a list of supported operating systems and any additional software programs that should be install on the virtual machine.

The preconfigured template-based solution is more suited for offering virtual laboratories, since the templates can be prepared in advance, tested and the virtual machines are created faster when using templates. The main disadvantages of this approach are that it requires careful planning, template creation requires more time to be created and tested and is less flexible to change requirements comparing to the on-demand solution.

The custom creation of virtual machines offers great flexibility, but creates problems for the usage planning of cloud resources. For this approach the resources made available need to be defined and configured as predefined components that can be combined on-demand by the user. In this case, an on-demand virtual machine will be composed of preconfigured components like hardware configuration, supported OS and applications.

2.4. Resource allocation and scheduling

VLCS uses role-based access control (RBAC) [11][12] to manage user access and permissions. The roles defined in VLCS are independent of the security mechanics available in Cloud Management Systems or Course Management Systems. Currently VLCS defines the following roles, which can be further extended if needed: Manager, Environment Administrator, Content Generator, and Content Consumer.

The resource allocation request contains information about the user who will administer the virtual machine(s), the course for which the resources are requested, the hardware and software requirements and time limits for the availability of the cloud resources. The resource allocation request needs to be approved by the VLCS Environment Administrator before the actual resources are allocated. The Environment Administrator allocates resources only to the course level. The Content Generator is responsible to further allocate the resources to laboratories and Content Consumers (students). For example, a professor (Content Generator role) can request 30 virtual machines with the same hardware configuration. Then, 29 of these VMs will be allocated to students while one of these VMs can be configured as a licensing server to be used by the other 29 machines.

The lifecycle of a virtual laboratory (figure 1) is composed of the following elements:

- *Allocation of cloud resources to a course*. This step is usually performed by the VLCS Content Generator and the request is approved by VLCS Environment Administrator.
- *Defining the virtual laboratory* inside a course. This step is done by the VLCS Content Generator. There can be multiple virtual laboratories for one course, all sharing the cloud resources allocated at the course level.
- *Allocation of cloud resource to the virtual laboratory*. In this step the VLCS Content Generator defines which cloud resources allocated for the course are going to be available for the current virtual laboratory
- *Allocation of users to the virtual laboratory*. Before the VLCS Content Consumers can use the virtual laboratory the corresponding users need to be added to the current virtual laboratory. This step is done by the VLCS Content Generator. User permissions are also defined at this step.
- *Configuring the virtual laboratory*. At this step the VLCS Content Generator needs to define the VMs configuration, virtual network configuration and the schedule.

- *Publishing or activating the virtual laboratory*. Only after a virtual laboratory is published the VLCS starts reserving the resources according to the desired schedule. This step is done by the VLCS Content Generator.
- *Hiding or deactivating the virtual laboratory*. When managing the schedule of cloud resources VLCS does not take into account the resources and schedules of inactive or paused virtual laboratories. This step is done by the VLCS Content Generator.
- *Save the virtual laboratory configuration*. This step, performed by VLCS Content Generator, is useful in order to recreate or restore a virtual laboratory at a later time. The saved information about of a virtual laboratory can include name, description, resources allocated, users allocated, VMs configuration, virtual network configuration, schedule and usage history.
- *Removing the users from the virtual laboratory*. This step can be performed automatically by VLCS or manually by VLCS Content Generator before removing a virtual laboratory.
- *Release the cloud resources allocated initially to the virtual laboratory*. This step can be performed automatically by VLCS or manually by VLCS Content Generator
- *Delete the virtual laboratory*. This step is done by the VLCS Content Generator.
- *Release cloud resources allocated to the course*. This step can be performed automatically by VLCS or manually by VLCS Content Generator. The release of resources can be done partially or totally, if all the virtual laboratories for that course are deleted.

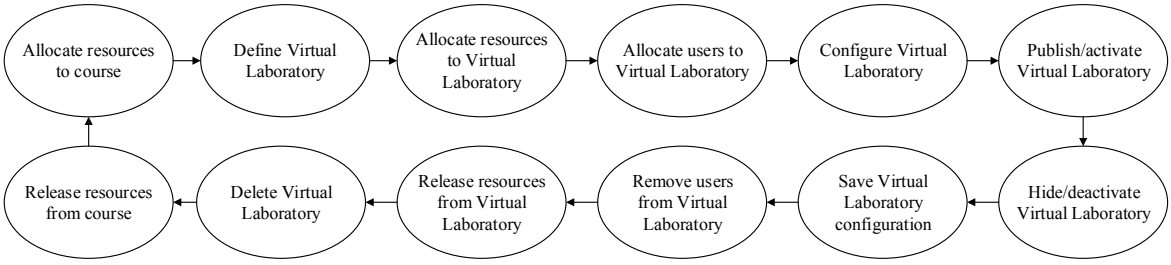

Figure 1. Virtual Laboratory lifecycle

In order to schedule the use of cloud resources the following scenarios are covered by the VLCS, regarding the allocation of virtual machines: one or more virtual machines per user (personal desktop) [13] or per group of users (pooled desktop) [14], with continuous uptime of the machine or planed (limited) uptime of the machine

The limited or planed uptime of the virtual machine refers to the period of time when the machine should be available to use. Since this scenario can apply to the academic environment, the number of users who can benefit from VLaaS can dramatically increase when comparing to the continuous availability of virtual machines.

3. Related Work

The most related or similar work to the VLCS presented in this paper includes Virtual Computing Laboratory (VCL) [15], Bluesky cloud framework [16], CloudIA [17], Snow Leopard Cloud [18], RESERVOIR [19].

All of these are focused mainly on the management of the cloud infrastructure, while the VLCS focused on linking the cloud infrastructure with the e-learning environment.

4. Conclusions

The proposed VLCS creates a new link between cloud computing and e-learning by providing virtual laboratories as a service to as many users as possible while increasing the utilization of private cloud resources. This approach offers the opportunity to enhance the e-learning experience with new ways of teaching.

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